Cascade Version 1: User's Guide

By Kenneth J. Connell and Nicholas C. Kraus

PURPOSE: This technical note is a user's guide for Cascade Version 1, distributed in the Surface-water Modeling System (SMS). The SMS is a Graphical User Interface (GUI) for generating, controlling, executing, and analyzing Cascade model simulations. Cascade and the Cascade interface are being developed under the System-Wide Water Resources Program (SWWRP). The interface, control options, data import and export features, and data analysis are described herein.

BACKGROUND: Cascade is a numerical model developed to simulate long-term, regional sediment transport and coastal evolution (Larson et al. 2002; Larson and Kraus 2003). The evolution of multiple interacting coastal areas, such as inlets and the adjacent beaches, can be simulated. The name Cascade refers to the concept of different time and space scales that cascade from long to short and from large to small, respectively, over which long-term calculations of coastal morphology change occur and must be simulated. Calculation scale and resolution vary depending on the physical processes that govern the scales controlling morphology response at the site. Version 1 of Cascade calculates wave-induced longshore sediment transport rates, shoreline change, and tidal inlet shoal volumes and natural bypassing employing the Inlet Reservoir Model (Kraus 2000, 2002). Cascade Version 1 theory is described by Larson et al. (2002), Larson and Kraus (2003), and updated in a SWWRP technical note (Larson et al. 2006), which can be consulted for technical background. Version 2 of Cascade, under development, will allow calculation of several cross-shore processes such as overwash, breaching, and wind-blown sand transport that contribute in determining long-term coastal change.

The interface allows engineers and scientists to implement and apply Cascade to projects in an efficient way, while reducing potential errors in model setup. The interface is distributed in stand-alone SMS format that is widely known in the coastal modeling community, making menus and project setup familiar to users of other SMS models (Zundel 2005). The Cascade interface gives users the capability to import or create new shorelines and boundary data sets, enter project-control parameters, execute Cascade, analyze output of simulations, plot results in report-quality graphics, and export the resulting data for further analysis.

CASCADE SMS INTERFACE: The Cascade interface is a stand-alone system with many of the features found in SMS that houses large numerical models for simulating waves, circulation, water quality, sediment transport, and morphology change. The interface is supported in the

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Microsoft Windows®[1] operating system and requires memory and speed resources typically available on office-environment personal computers. The Cascade interface has four sections (Figure 1) as follows:

1. *Project Menus and Toolbar*. This section allows the user to open and save projects, transform coordinates, generate grids and shoreline position files, alter the model controls, and access the control databases.

2. *Data Tree*. The data tree displays the active grid, the output shoreline data files, and the specified output time-steps.

3. *Grid/Map Viewer*. The Grid/Map view gives the capability to visualize the grid and shoreline locations as well as access to grid cell selections for adding and changing coastal features.

4. *Solution Plots of CASCADE Menu*. The solution plots window offers visualization of the output data with selectable plots of longshore sediment transport rates along the coast, shoal volume evolution at inlets, and cumulative morphology change in shoreline as caused by structures, storms, and dredge and fill projects.
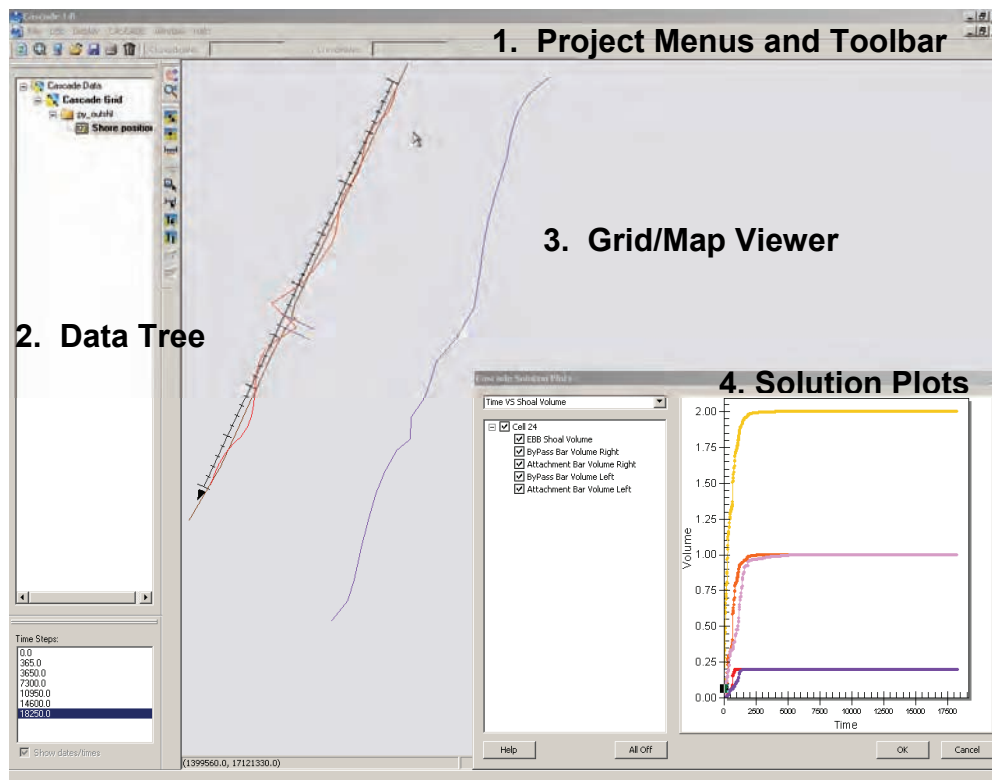
Figure 1. Cascade interface with (1) Project Menus and Toolbar, (2) Data Tree, (3) Grid/Map Viewer, and (4) Solution Plots window.

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[1] The contents of this technical note are not to be used for advertising, publication, or promotional purposes. Citation of trade names does not constitute an official endorsement or approval of the use of such products.

The Cascade SMS interface contains standard Windows® functionality and provides a modeling environment that is intuitive and familiar to most users that have worked in a menu-driven operating environment. The various pull-down menus for operating Cascade Version 1 are summarized in Table 1. These menus contain the input/output variables, display settings, and model controls for the Cascade global environment.

Table 1
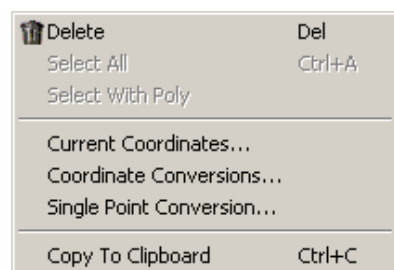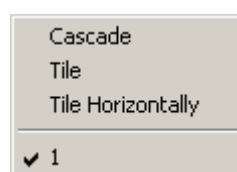**Cascade Version 1 Pull-Down Menus**

Cascade Interface Task Bar

File Menu
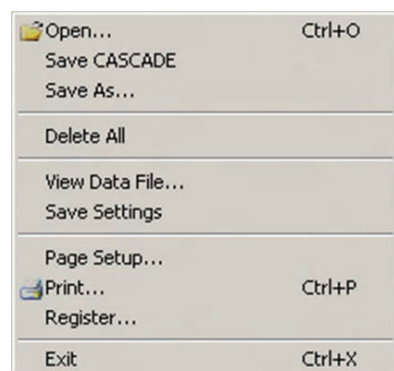
Cascade Menu

Edit Menu

Window Menu

Display Menu
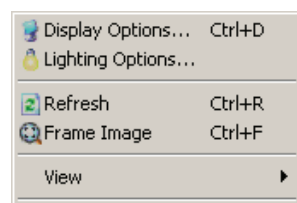
Help Menu
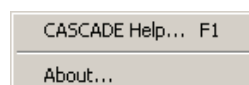
CASCADE INPUT/OUTPUT FILES: The Cascade interface generates a project file when a project is saved. The Cascade project file (*.csim) name is provided by the user and is generally given as the name of the project or simulation case (e.g., *Projectname.csim)*. This file functions as a pointer to link to the four (minimum) required Cascade input files (*.cinput, *.cinshl, *.cregshl, *.cwav), and it is also enlisted in loading the output files (*.cavq, *.cqtr, *.coutshl, *.cvol) into the interface. The results of a model simulation are written to four output files. The input and output files are described in Table 2.

Table 2
I/O File Descriptions

Input File Name	Type	Description
Projectname.csim	Cascade project file	Links input files to project for loading
Projectname.cinput	Cascade input control file	Contains main control flags and variables
Projectname.cinshl	Initial local shoreline file	x-y coordinates of initial local shoreline
Projectname.cregshl	Regional shoreline file	x-y coordinates of regional shoreline trend
Projectname#.cwav	Wave gauge file(s)	Wave height, period, and direction
* *Projectname.cebvol*	(*Optional) equilibrium volume file	Time-varying ebb shoal equilibrium volumes
Output File Name	**Type**	**Output Column Description**
Projectname.cavq	Mean longshore transport rate output	Distance along grid and average longshore transport rate
Projectname.cqtr	Longshore transport rate at specified times	Distance along grid and longshore transport rate at each time
Projectname.coutshl	Calculate shorelines at specified output times	x and y coordinates at each output time specified
Projectname.cvol	Calculated inlet shoal volumes	Shoal volumes at the specified output time

The Cascade control file (*Projectname.cinput* in Table 2) passes the user-defined variables and controls into Cascade. This file is generated by the interface when the user saves a project. Each of the control parameters in the Cascade control file is described in greater detail in Table 3.

Table 3
Model Control Specifications of *Projectname.cinput*

Parameter	Description
NDX, NDT	Number of alongshore grid cells, number of time-steps in simulation
XSTART, YSTART, DX, DT	x- grid origin, y-grid origin, cell size, model time-step in hours
D50, CF	Median sediment grain size, bottom friction coefficient
ICERC	Flag for varying transport rate coefficient in CERC formula
NCERC, ICT1, VCERC1, ...	Number of changes in the transport rate coefficient, cell location of first change in transport coefficient, value of first transport rate coefficient, …
IDCLOS	Flag for varying depth of closure
NDCLOS, ICL1, DVCLOS1, ...	Number of changes in the depth of closure, cell location of first change in depth of closure, value of first depth of closure, …
CBP, CAC, CEC	Bypassing calibration coefficient, power in nonlinear Inlet Reservoir Model during accumulation of sediment, power in nonlinear Inlet Reservoir Model during depletion of sediment
NPRINT	Number of output time-steps to print
IPR(I)	Output time-steps to print
NWFIL	Number of wave data files
FILNAM	Name of each wave data file
IWBND, WMDEP	Grid cell number at which the wave data are located offshore of, depth at which the wave data are taken (these are repeated for each wave file)
TRANG	Wave angle between wave and shoreline reference systems
NQVAL	Total number of boundary conditions
NQB, IQB	Cell at which a boundary condition exists, type of boundary condition (see Table 4)
NRJTIM	Number of changes in jetty length
IJTIM, SJETL, SJETR	Time at which change in jetty length takes place, length of left jetty (from perspective of standing onshore looking offshore), length of right jetty (from perspective of standing on shore looking offshore)
ISTEMP	Flag for equilibrium shoal volume
VSEQ, VSBQ, VSAQ	Ebb shoal equilibrium volume, bypassing bar equilibrium volume, attachment bar equilibrium volume
CSB, CSA	Relative ratio between VSBQ and VSEQ, relative ratio between VSAQ and VSEQ
VSE	Initial ebb shoal volume
VSBP, VSBN	Initial bypassing bar volume of: bar on right side (from perspective of standing onshore looking offshore), and bar on left side (from perspective of standing onshore looking offshore)
VSAP, VSAN	Initial attachment bar volume of: bar on right side (from perspective of standing on shore looking offshore), and the bar on left side (from perspective of standing onshore looking offshore)
	(Continued)

Table 3 (Concluded)	
Parameter	**Description**
NDIS	Number of cells over which sediment is added or removed around an inlet
NSPR	Increment of time-steps at which shoal volumes are printed as output
ISOUR	Flag for distributed sediment sources
NSOUR	Number of distributed sediment sources along grid
NRST	Number of changes of rate of sediment input or removal
XBS	Location of starting point of sediment input or removal
XES	Location of ending point of sediment input or removal
ISTIM	Time at which rate of input or removal changes
QD	Rate of input or removal of sediment
IPOINT	Flag for shoal volume of sediment to be added or removed at an inlet
NRINL	Boundary location number
IMORFE	Inlet morphological feature (shoal/bar) number: 1. Attachment bar, left side (from the perspective of standing onshore looking offshore) 2: Bypassing bar, left side 3: Ebb shoal 4: Bypassing bar, right side 5: Attachment bar, right side
NTMORF	Time-step at which shoal volume is added or removed at an inlet
DELTAV	Volume of sediment added or removed

Four lateral and internal boundary conditions are available in Cascade Version 1. These are defined in the control file (Table 3) as a numerical value given by the *IQB* parameter. The lateral boundaries may be set to allow no transport across that boundary or to have the same amount of transport as the prior calculation cell as in the pinned beach case. Internal barriers may be represented by boundary conditions that allow bypassing without shoal change, or bypassing with shoal volume input and removal modeling. Shoal evolution in the latter boundary condition is driven by the Inlet Reservoir Model (Kraus 2000, 2002). The values that flag each of the four types of boundaries are listed in Table 4.

Table 4 **Boundary Conditions in Cascade**	
Value of IQB Index	**Description**
1	No transport, $Q(I) = 0$
2	Pinned Beach, $Q(I) = Q(I+1)$
3	Bypassing (e.g., groin)
4	Bypassing with shoal volume input and removal modeling (e.g., at an inlet)

Initializing a Cascade project. Prior to opening or starting a new Cascade simulation, the coordinates should be changed as necessary to represent the project coordinates. This is accomplished by entering *Current Coordinates…* (Figure 2) under the *Edit* menu and selecting the horizontal and vertical coordinate systems that relate to the project.
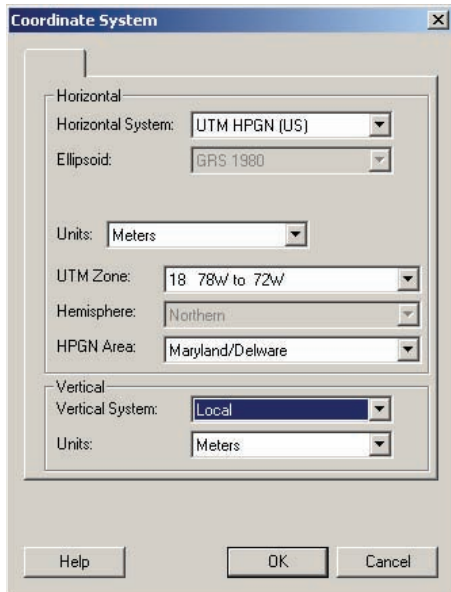

Figure 2. *Current Coordinate System* window

Generating the grid. Once the coordinates are set to the project coordinates, a baseline grid may be developed. The Cascade grid is composed of a 1-D baseline from which shoreline positions and calculations within the model domain are referenced. The grid is subdivided into numerous calculation cells. The size of the grid cells determines the spatial resolution of the model domain. The user defines the grid origin, azimuth in degrees referenced from grid north, the number of calculation cells and the size of the cells (cell size is uniform along the grid). The baseline grid is initially generated by selecting *Create Grid* under the *Cascade* menu. This command generates a default grid and opens the *Grid Position* window (Figure 3), which gives the user the ability to change the x- and y-coordinates of the origin, the azimuth of the grid, the number of cells, and the size of each cell. Also given in this window is the length of the grid computed from the cell size and the number of cells. This window may also be accessed at any time by clicking on the [icon] **edit 1-D** grid button. Alternatively, the user may click on the grid with the mouse pointer and drag and rotate the grid to the desired position.
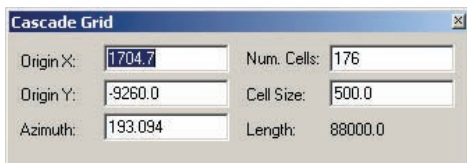

Figure 3. Grid position window

Shorelines. Cascade requires two shoreline files to execute coastal change calculations. First, an initial local shoreline is created. The initial shoreline represents the shoreline position at the beginning of the Cascade simulation. Second, a regional shoreline is created to represent the regional shoreline trends across the model domain. The regional shoreline may be depicted as an offshore contour, or as an average of many local shorelines.

There are several methods for interpreting shoreline positions from various data sources (Kraus and Rosati 1998). The interface provides several options for handling and developing shorelines. Shoreline positions may be created within the Cascade interface by first selecting *Set Active Coastline* under the *Cascade* menu and choosing the initial or regional coastline in the *Set Active Coastline* window (Figure 4).
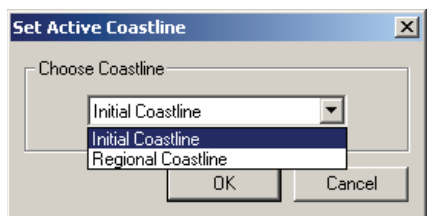
Figure 4. *Set Active Coastline* window

Once the desired shoreline is set to active, the user may click on the [icon] **create coastline point** button to create any number of coastline points in the Grid/Map Viewer area. If the user desires to change a point along the shoreline after creating it, he/she can click on the [icon] **select coastline point** button and select and drag the point to the desired location, then release by releasing the mouse button. Further precise shoreline position editing may be conducted using the *View Coastline Data* editor (Figure 5) under the *Cascade* menu.
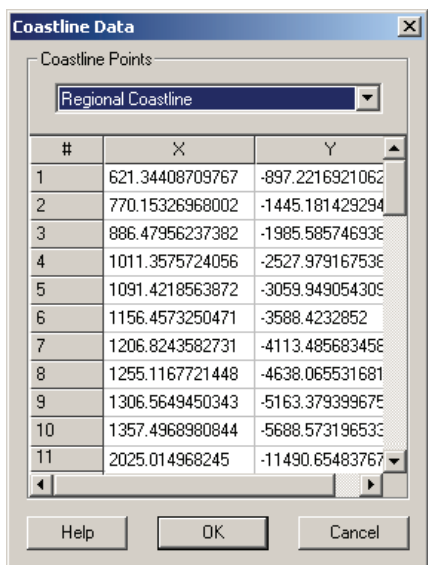

Figure 5. *View Coastline Data* editor

Once the initial shoreline is complete, the user would then set the regional coastline as active and follow the same steps to creating the regional shoreline. Alternatively, one may create shorelines outside of the Cascade interface and import the shoreline files by selecting *Open…* under the *File* menu and selecting the desired shoreline file that is formatted in a space-delimited two-column (x- and y-coordinates) style with a single header line containing the number of points in the shoreline file. The Regional Morphology Analysis Package (RMAP) (Batten and Kraus 2005) facilitates file transfer between RMAP and the Cascade interface, and RMAP is a recommended analysis package for assisting in the creation of the initial and regional shoreline position files for Cascade. RMAP can also assist in creating, checking, and visualizing intermediate measured shoreline position files for comparison to Cascade predictions.

After the grid and shoreline positions are in place, the user may set up the model controls and add the boundary conditions specific to the project. These may include wave measurements at multiple locations, inlets with or without jetties, groins and other structures, dredging and fill at specified times within the simulation period, and bars and shoals of varying sizes at each inlet.

Cascade controls. Cascade controls are accessed by selecting *Model Control…* under the *Cascade* menu. The *Model Control* window (Figure 6) is where model parameters and coefficients, lateral boundary conditions, and time controls are specified. This control window is where the majority of the parameters in the *Projectname.cinput* file (Table 3) are defined.

Figure 6. *Model Control* window

The first control parameter in the *Model Control* is the depth of closure. The depth of closure may be set as a single value for the entire domain or as variable with multiple values assigned along the model domain. If the user selects *Single Value* for depth of closure, the value is then entered in the space provided next to the *Single Value* radio selection button. If the user selects *Multiple Values* for depth of closure, then the values are assigned to cells in the space provided for *Depth of Closure* in the top portion of the *Cell Attributes* window (Figure 7). The next control parameter to be entered is the median D_{50} grain size. The bottom friction coefficient c_f is designated in the next provided space. The Cascade interface sets this bottom friction coefficient at a default value of 0.01, a recommended value for sandy beaches (Longuet-Higgins 1970; Thornton and Guza 1981; Headquarters, U.S. Army Corps of Engineers 2000). Similar to the depth of closure parameter, the coefficient from the CERC sediment transport formula may also be applied as constant for the entire domain, or variable by cell. If a variable transport coefficient is selected (i.e., *Multiple Values* radio selection button), the values are input into the space provided for the *Transport Coefficient* also in the top portion of the C*ell Attributes* window (Figure 7). The next parameter in the *Model Control* is the number of cells around an inlet to add or remove sediment, which is represented by the *NDIS* value in Table 3. The bypassing calibration coefficient (*CBP* in Table 3) is entered in the next space. Finally, the exponents of the nonlinear Inlet Reservoir Model (Larson et al. 2002) during accumulation (*CAC* in Table 3) and depletion (*CEC* in Table 3) are designated in the last two spaces provided. The default values for the accumulation and depletion exponents of the nonlinear Inlet Reservoir Model are allocated as 1.0, representing periods of growth in shoal volume (Larson et al. 2002).

Figure 7. Wave and cell attributes

The *Model Control* menu is also where the lateral boundaries and time controls are assigned. The user defines the output time-steps to write shoreline evolution files by clicking on the **Output Times** button. Selection of this button opens the *Output Times* window shown in Figure 8.
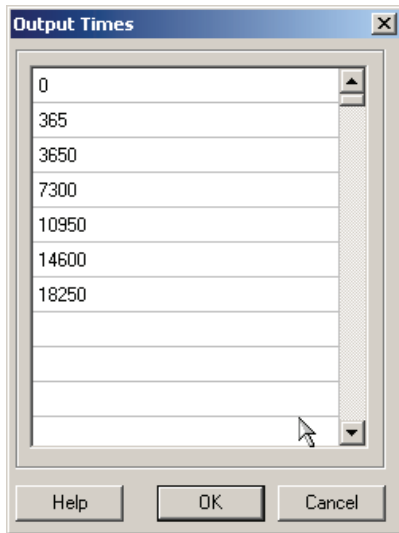
Figure 8. Specified *Output Times* editor

Wave conditions. Wave information is needed to generate longshore sediment transport rates in Cascade. This information is user-defined in the interface or imported from an external source and provided to Cascade by the wave information file(s) (*Projectname#.cwav* in Table 2). Cascade requires wave height, period, and direction as forcing condition input. The source of these data may be wave gauges, wave model output, wave hindcasts, or hypothetical wave conditions. The Cascade interface gives the user the capability to select any depth in any cell along the grid as a location for wave information (e.g., wave gauge location), as well as the capability to represent any number of wave information input locations. To do this, select the 🔍 **select a grid cell** button and then click on the grid cell where the wave gauge is to be located. This procedure opens the *Wave Cell Attributes* window (Figure 7) where the *Add* button adds a wave gauge. At this point, the wave gauge may be renamed to a unique identifier; the depth at which the wave gauge is located must be entered; and data may be hand edited or pasted in from another file in the wave data editor. The resulting wave information file(s) represent the wave data to Cascade in the format described by Table 5.

Table 5
Wave Data File (*Projectname#.cwav*) Column Format

Column 1	Column 2	Column 3
Wave height (vertical length units set in SMS)	Wave period (seconds)	Wave direction (degrees from north)

Inlets. Coastal inlets and structures located along the shore will alter the local longshore transport rate and create characteristic trends of shoreline change. The Cascade interface allows one or several inlets to be represented in cells along the grid. To do this, select the 🔲 **create an inlet** button and click on the grid cell where the inlet will be located. When this is done, a pair of lines perpendicular to the grid will appear. The inlet case is represented as an internal boundary condition and inlet calculations are made at the boundary of two cells. The 🔲 **select an inlet**

button selects the perpendicular inlet lines. A pair of selection handles will appear at the offshore ends of the inlet lines when the inlet is selected. The user may then select *Attributes* under the *Cascade* menu to view the *Inlet Attributes* window (Figure 9).

Figure 9. *Inlet Attributes* window

The *Inlet Attributes* window is where the user assigns the control parameters specific to cell boundaries that have been designated as inlets. These include jetty lengths, initial and equilibrium inlet shoal and bar volumes of the morphological features associated with an inlet, time-varying equilibrium shoal volumes, and volumes dredged or filled into each of those morphological features.

The user has the choice of selecting either a fixed equilibrium shoal volume or a time-varying equilibrium shoal volume. If the fixed equilibrium shoal volume option is selected, an estimated or measured equilibrium shoal volume for each of the morphological features associated with the ocean side of the inlet is entered: ebb shoal, bypassing bar, and attachment bar. If the time-varying equilibrium shoal volume option is selected, the relative ratio between the bypassing bar and the ebb shoal equilibrium volumes and the ratio between the attachment bar and the ebb shoal equilibrium volumes are entered. A data file named *Projectname.cebvol*, which contains an ebb shoal equilibrium volume for each time-step is then created by selecting the **VSEQ** button. This file is used to control the relative growth of all of the inlet shoals and bars. Cascade then models shoal evolution using these constant ratios to allow equilibrium volumes that vary through time. This method is necessary for calculating shoal volumes where inlet cross-sectional area changes over time (Larson et al. 2002).

The lengths of jetties at an inlet may be entered by selecting the **Inlet Tip Position** button, which opens the *Jetty Tip Position* window (Figure 10). Jetty length may be altered throughout the

simulation period to account for changes to the structures in long-term model simulations. Changes in jetty length are implemented by adding multiple times and lengths by clicking the **Add** button and inputting the values that correspond to the time period.
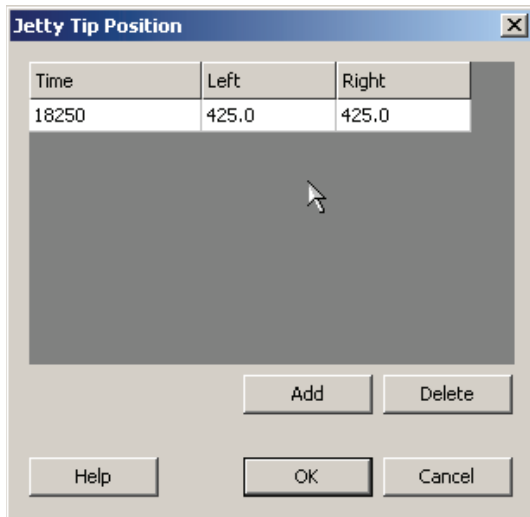

Figure 10. *Jetty Tip Position* window

Dredge and fill project fate may also be modeled by first checking the box next to *Shoal Dredge/Fill* and then selecting the **Attributes** button. This action opens the *Shoal Dredge/Fill Attributes* window (Figure 11), which gives the user the capability to select different morphological features and add or remove a volume of sand at time-steps corresponding to dredging and fill projects.
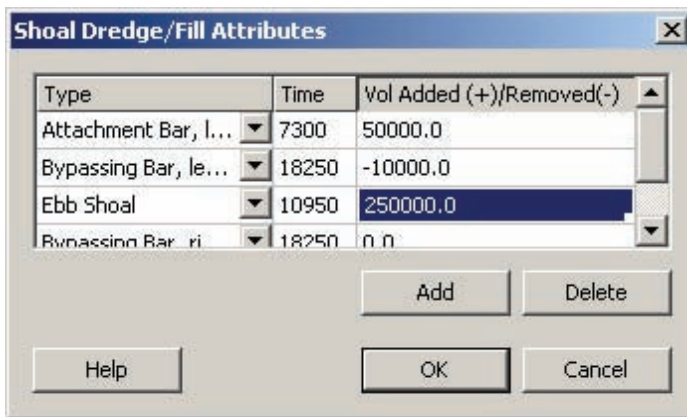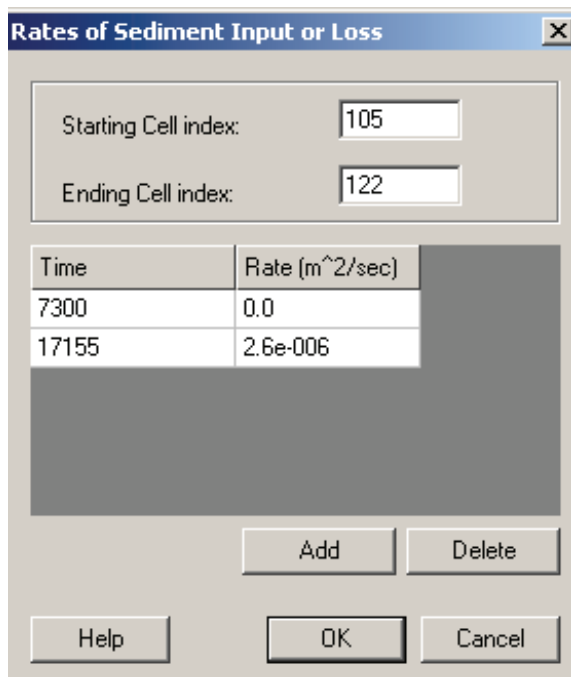

Figure 11. *Shoal Dredge/Fill Attributes* window

Sediment Sources. Sediment sources, such as beach fills and input from cliff erosion, as well as sediment sinks such as submarine canyons, can be represented by accessing the *Source/Sink Attributes* menu. The user must specify the location and rates of input or loss of the source or sink, respectively. Sediment source locations may be added to the modeling domain by selecting the ▥ **create sediment source/sink** button on the toolbar and clicking and holding the left mouse button at the starting grid cell then dragging to the desired ending grid cell and releasing the left mouse button. The rates of input or loss and the cell locations may then be adjusted by clicking on the ▥ **select sediment source/sink** button, then selecting the graphic handle

associated with the sediment source/sink region created, and selecting *Attributes* under the *Cascade* menu. This opens the *Source/Sink Attributes* window (Figure 12), which gives the user the capability to assign a time and a rate of sediment input or loss to the region defined by the ![icon] **create sediment source/sink** button. Similar to other time-varying parameters in Cascade, the time listed represents the time at which the conditions change. The condition shown at that time is the condition that is valid up to that time. The user may also redefine the sediment source/sink region by changing the starting and ending cell indices in the top section of the window shown in Figure 12.

Figure 12. *Sediment Input or Loss* attributes

EXECUTING CASCADE MODEL RUN: The Cascade interface integrates the model so that all component calculations (wave transformation, sediment transport rate, shoreline change, inlet shoal evolution, etc.) are executed within the interface environment. Once the Cascade project is specified and input variables and boundary conditions assigned, the model may be run. Prior to execution, it is recommended that the Cascade project be saved. In fact, during the project setup process, work should be saved frequently, such as after entering various blocks of information. To save, select *Save Cascade* or *Save As…* under the *File* menu. This action will create or save a project file (*Projectname.csim*) and the associated input files (*.cinput, *.cinshl, *.cregshl, *.cwav).

Figure 13 illustrates an example of a project that is ready to begin a simulation. A model run is executed by selecting *Run Cascade…* under the *Cascade* menu. When the model is executed, the user will see the model run status window (Figure 14) printing the progress of the simulation. The model run status window reports information about progress of the simulation and also displays error messages if program termination should occur due to, for example, incorrect or insufficient input data. When the progress bar reaches 100 percent, and the model status window reports that the run has completed, the user may then open and view the output data.
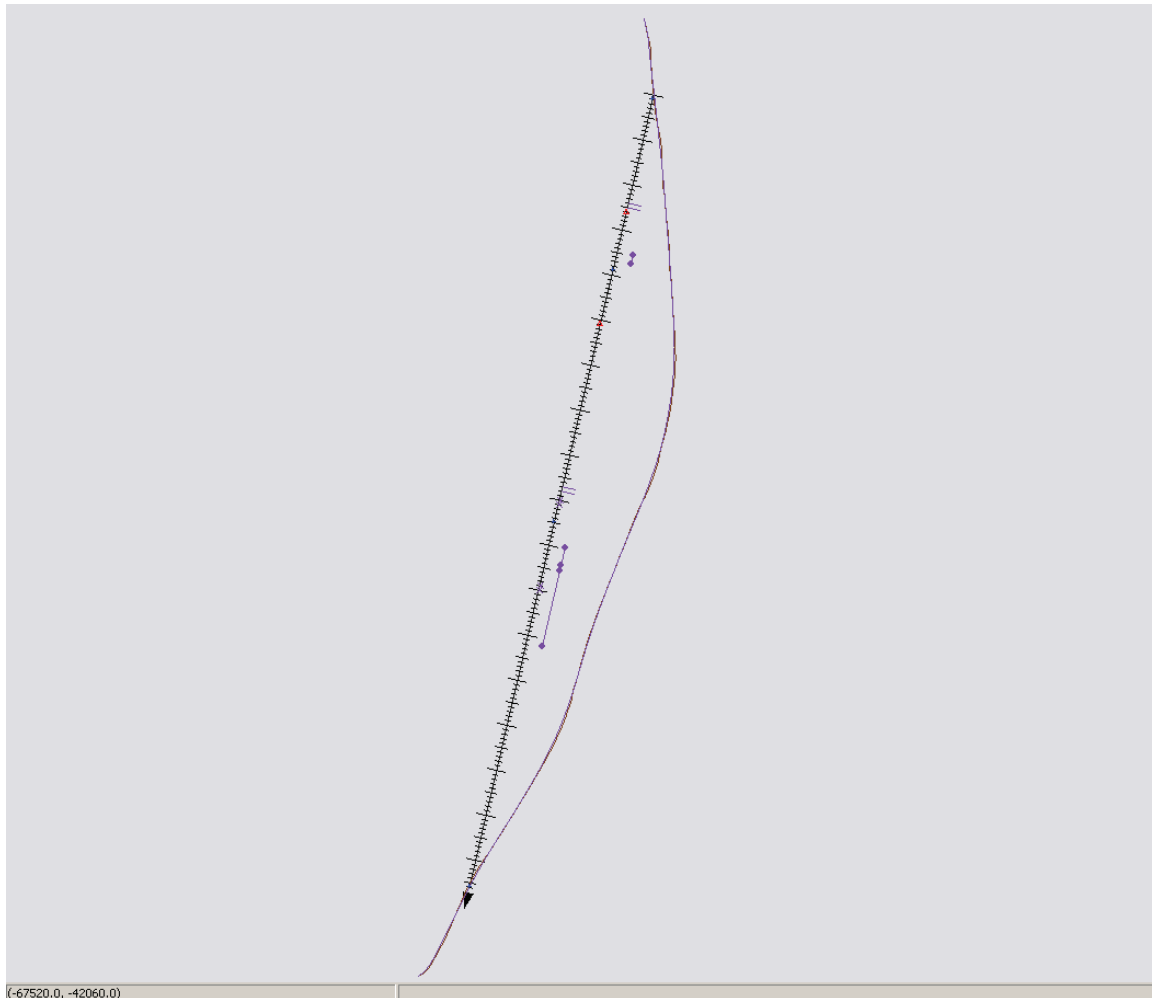
(-67520.0, -42060.0)

Figure 13. Complete project (Delmarva Peninsula) prepared to be run in Cascade
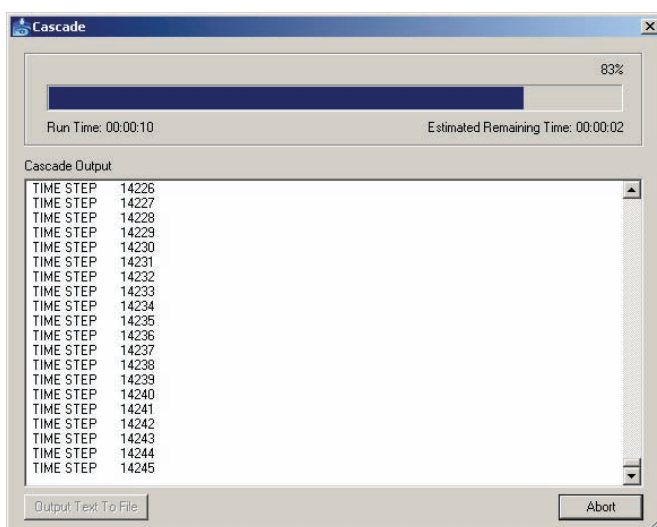

Figure 14. *Cascade* run status window

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Cascade Output. A successful Cascade simulation will generate four output files (Table 2) and place them in the current project directory. To view these data, the project must be reloaded into the Cascade interface. To reopen the project, select **Open…** under the *File* menu, select the Cascade project file (*Projectname.csim*) that completed its simulation, and press **OK**.

There are two options for examining and analyzing the Cascade output data in the interface. The output shoreline data file (*Projectname.coutshl*) may be viewed at each specified output time-step by first selecting *Shore Position* in the upper portion of the File Tree section, and then selecting the desired output time-step in the lower portion of the File Tree section (Figure 15).
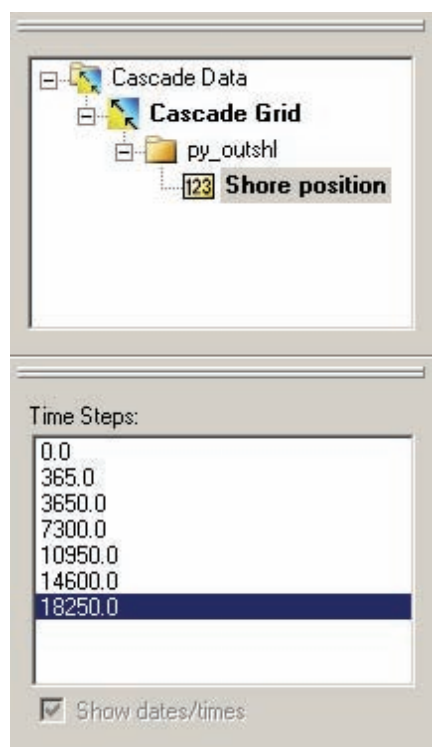

Figure 15. File Tree shore position and output time-step selection

The modeled shoreline at each output time-step will be displayed superimposed over the initial and regional shorelines in the Grid/Map viewer section of the interface (Figure 16). The user may also generate an **.avi* animation of the shoreline change throughout the simulation by selecting *Film loop…* under the *Cascade* menu.
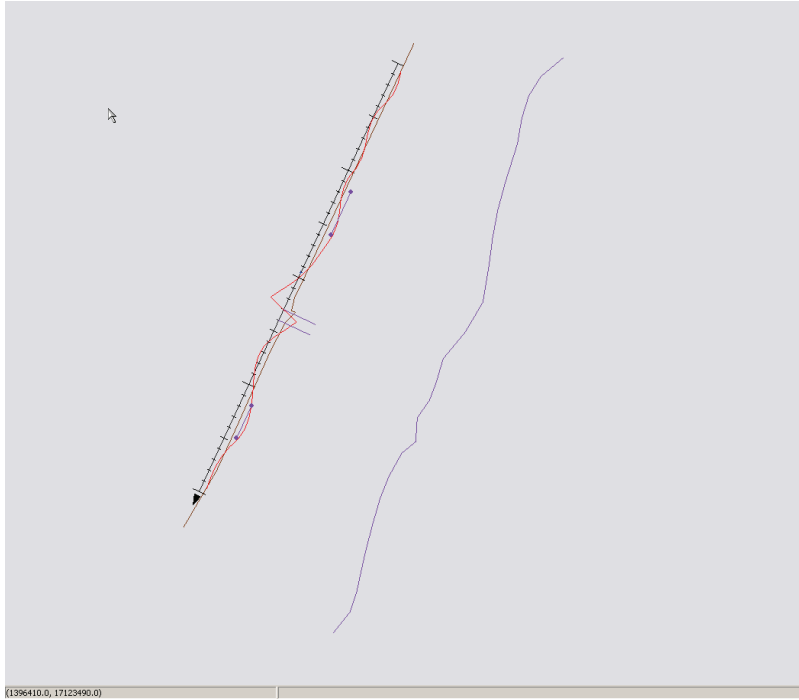
Figure 16. Output shoreline spatial change (in red) in Grid/Map viewer

The second option for analyzing Cascade output files is through the *Cascade Solution Plots* window (Figure 17). The solution plots give the user a direct means of examining the longshore sediment transport rate and shoal evolution without exiting the Cascade interface environment. The *Solution Plots* window is accessed by selecting **View Solution Plots** under the *Cascade* menu. The pull-down selection in the upper left region of the window allows selection of the type of plot as Time vs. Shoal Volume (Figure 18), Distance vs. Transport (Figure 19), Computed Coastline Position (Figure 20), and Distance vs. Mean Transport (Figure 21). Display properties (Figures 22-28) are configured by the user in order to customize report quality plots, which may be exported to a variety of graphic formats.
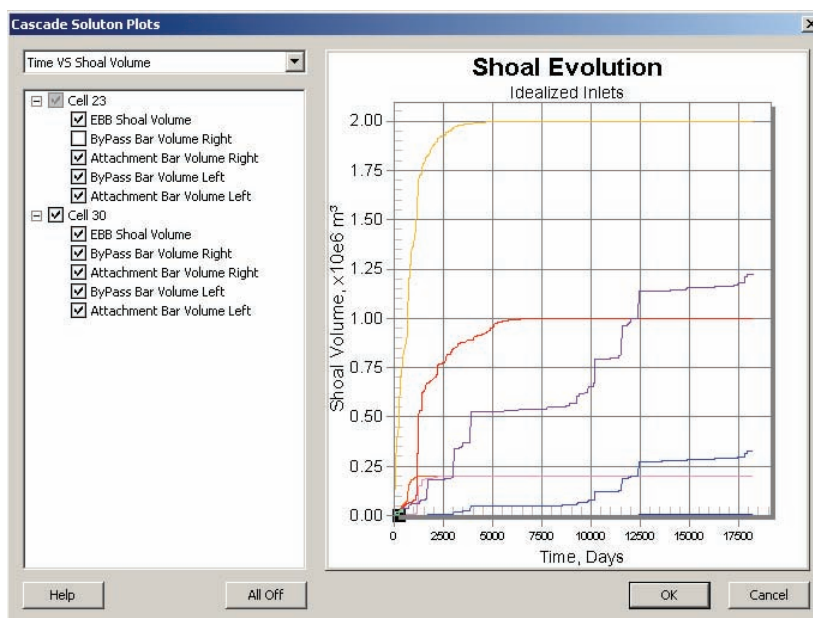

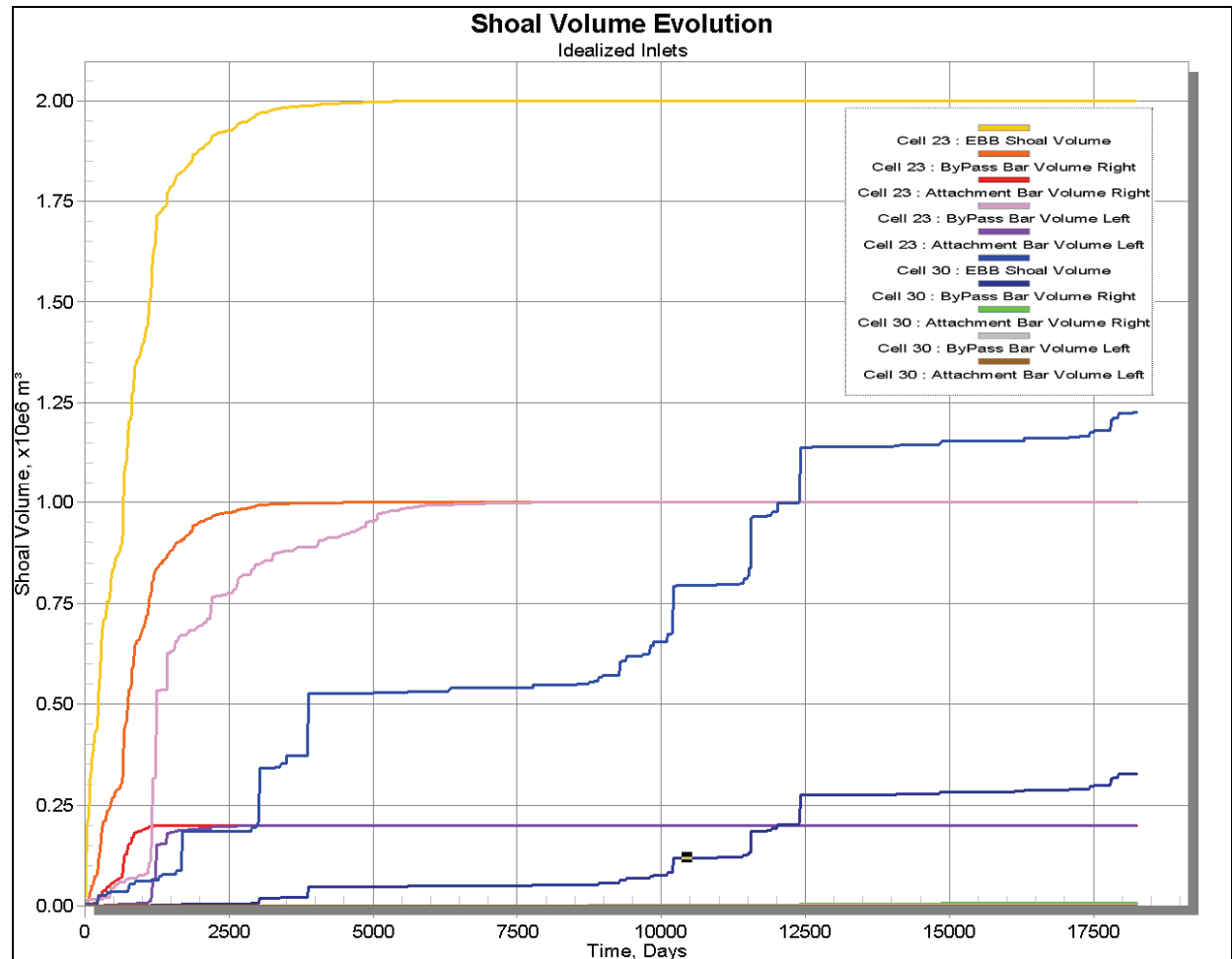Figure 17. *Solution Plots* window

Figure 18. Shoal volume evolution solution plot

Modeled shoal volume evolution (Figure 18) may be plotted for each morphological feature (i.e., shoal or bar) represented by the IMORFE value (Table 3) for each cell defined as an inlet. This plot provides a means of analyzing shoal growth toward an equilibrium state after an inlet breach or other user-defined initial condition. The long-term cumulative effects of sand mining or infill upon an inlet shoal may also be examined in the shoal evolution plot.
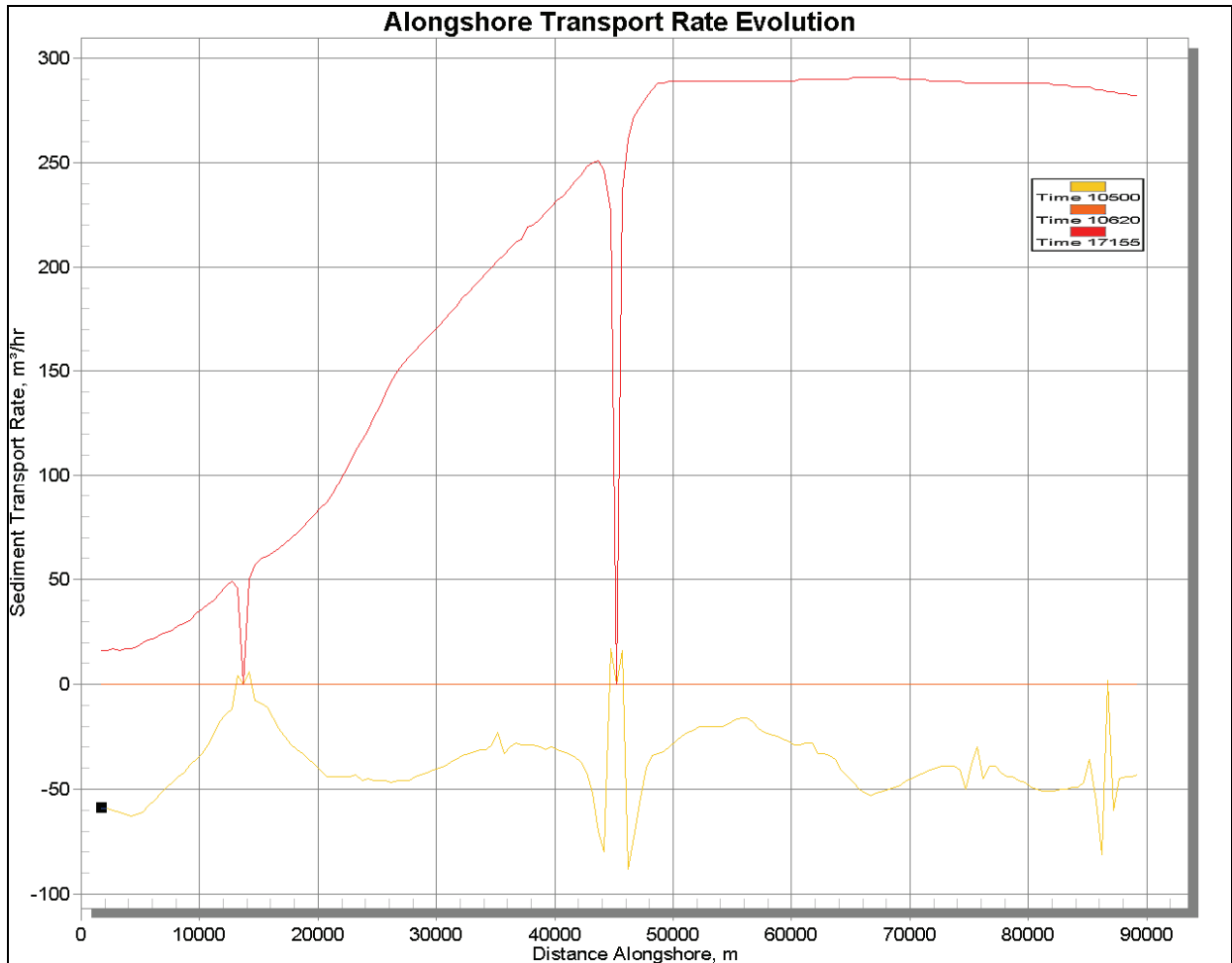
Figure 19. Sediment transport evolution solution plot

Sediment transport rates are written for each output time-step defined in the *Output Times* editor (Figure 8) of the *Model Control* window. Sediment transport rates may be plotted for the entire distance along the shoreline at each output time-step (Figure 19). The output time-steps are selectable so that the user may plot any combination of output times or all the output times together. The transport evolution plot is useful in examining changes in longshore sediment transport during, after, or prior to an event such as a storm or the construction of a coastal structure. Likewise, the plot is valuable in comparing modeled output against empirical data from field or laboratory measurements at specific times or under specific conditions.
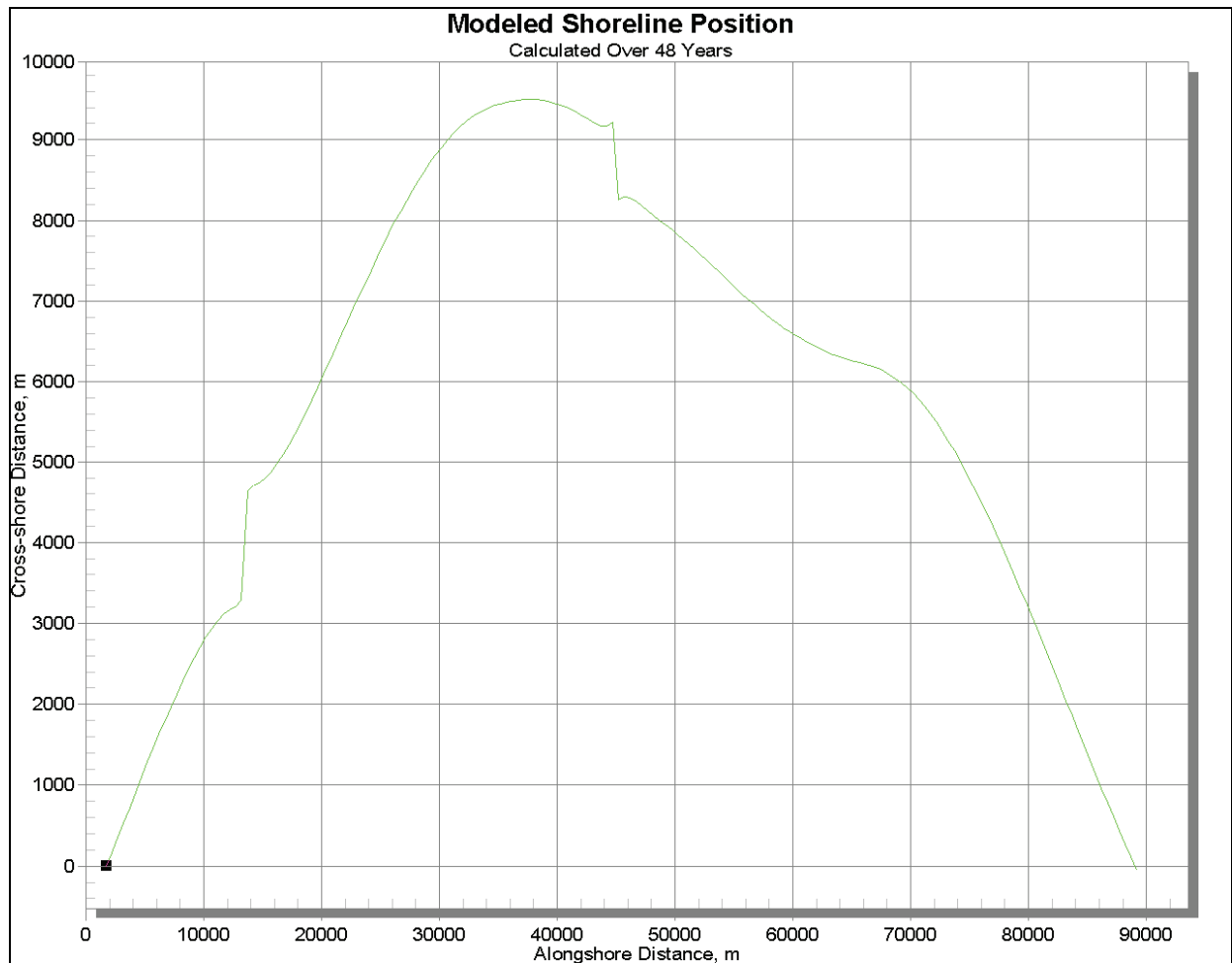
Figure 20. Computed coastline position solution plot

Although shoreline position evolution may be best examined in the Grid/Map viewer, shoreline positions may also be plotted on an x-y scatter plot (Figure 20) so that they may easily be exported as report figures. Shoreline positions may be plotted at each output time-step defined in the *Output Times* editor (Figure 8). This gives the user the flexibility to compare calculated shoreline output to measured shorelines extracted from aerial photographs or topographic surveys at a given time determined by the photograph or survey date. This is a practical tool for model validation and calibration of regional-scale coastal processes.
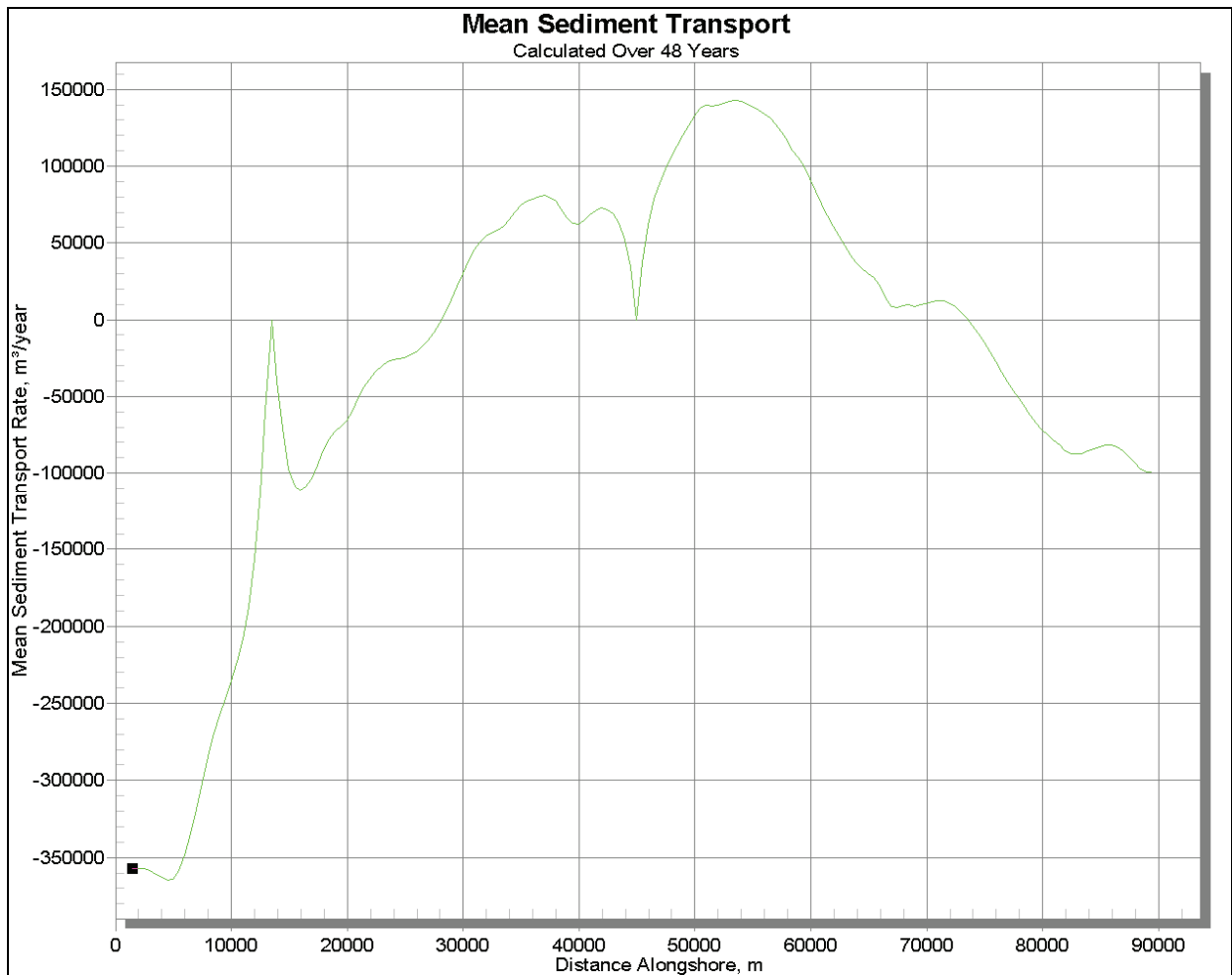
Figure 21. Mean transport solution plot

Sediment transport along the shoreline domain averaged over the entire simulation period (Figure 21) may also be plotted to examine transitional transport regions and cumulative impacts of structures or dredge/fill projects.

The user may customize the appearance and attributes of each of the solution plots by altering the display settings. The display settings (Figure 22-27) may be accessed by double-clicking on the plot region of the *Solution Plot* window, or by right-clicking on the plot and selecting *Display Options*. Likewise, the figure legend, exporting options, and full screen view may also be accessed by right-clicking on the figure.
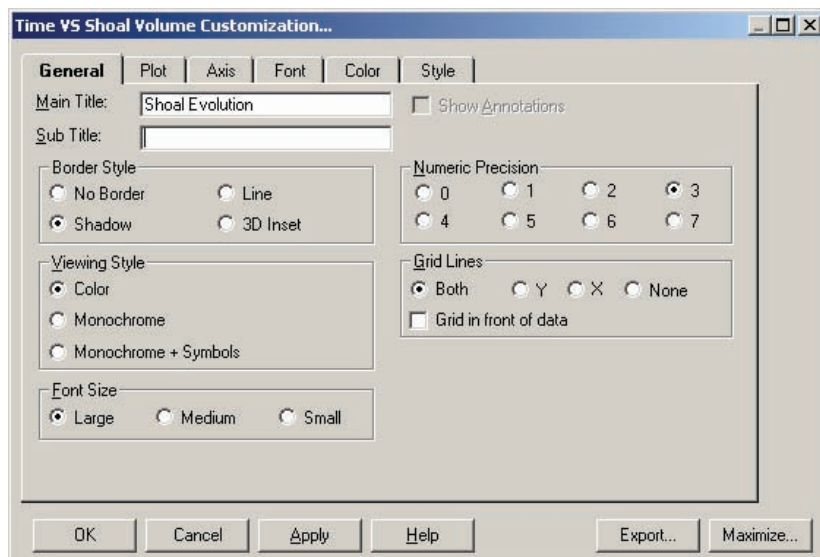
Figure 22. Solution plot display general options

The *General* tab of the display options (Figure 22) gives the user the capability to assign the figure title, subtitle, border style, numeric precision, viewing style, grid lines, and font size.
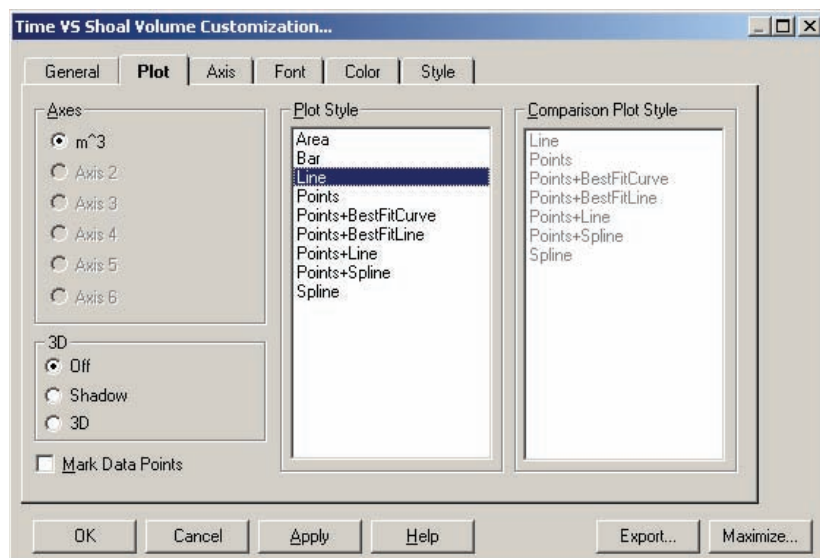

Figure 23. Solution plot display plot options

The *Plot* tab of the display options (Figure 23) is where the user may assign the type of plot and whether to include data point markers.
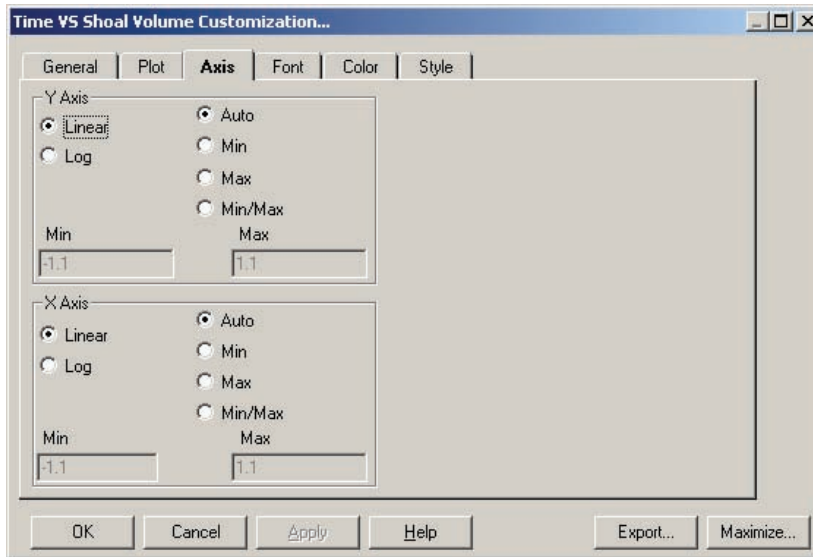
Figure 24. Solution plot display axis options

The *Axis* tab of the display options (Figure 24) gives the user the capability to assign the axis increment type (linear or log) and the axis numerical limits.
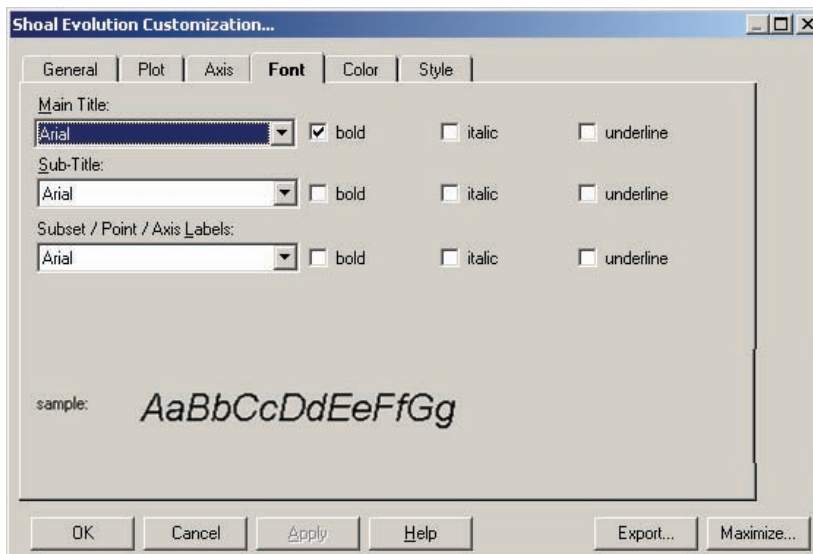

Figure 25. Solution plot display font options

Font types and formats are assigned in the *Font* tab of the display options (Figure 25).
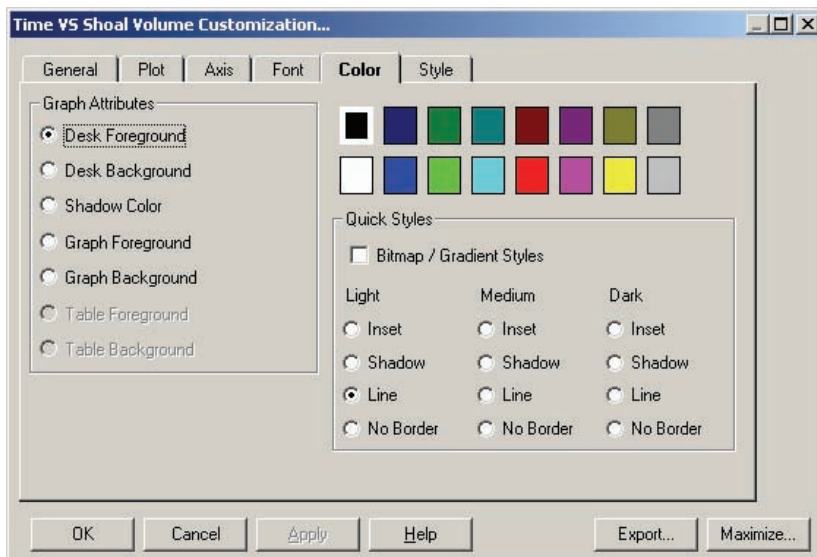
Figure 26. Solution plot display color options

Plot shading colors are assigned in the *Color* tab of the display options (Figure 26).
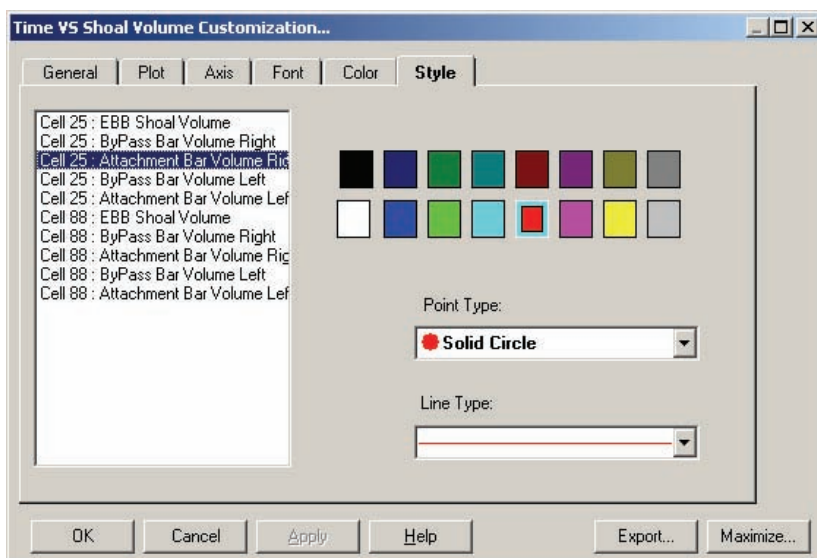

Figure 27. Solution plot display style options

The *Style* tab of the display options (Figure 27) gives the user the capability to assign the data and line styles and colors for each series of data.
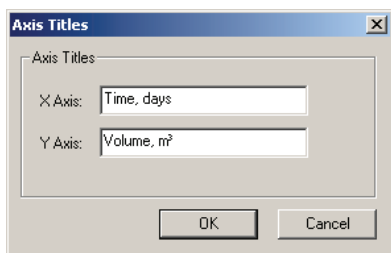

Figure 28. *Axis Titles* window

The axes titles are altered by double-clicking on either **axis** in the solution plot window to open the *Axis Titles* window (Figure 28).

The output files that are created by Cascade may also be examined in external programs such as RMAP and Matlab® for further analysis. The column format of the four output files listed in Table 2 is described in Tables 6-9.

Table 6 Mean Transport Output Data File (*Projectname.cavq*) Column Format	
Column 1	**Column 2**
Distance alongshore	Mean sediment transport (length^3/sec)

Table 7 Transport at Time Output Data File (*Projectname.cqtr*) Column Format	
Column 1	**Column 2 Through Column # (Number Determined by *NPRINT* + 1)**
Distance alongshore	Sediment transport (length^3/sec) at each output time-step

Table 8 Shoreline Position Output Data File (*Projectname.coutshl*) Column Format			
Column 1	**Column 2**	**Column 3**	**Column 4 Through Column # (Number Determined by *NPRINT* + 3)**
Distance alongshore	Original regional shoreline position	Original initial local shoreline position	Evolving shoreline position (length^3/sec) at each output time-step

Table 9 Inlet Shoal Volume Output Data File (*Projectname.cvol*) Column Format	
Column 1	**Column 2 Through Column # (Number Determined by the Number of Inlets Multiplied by the Five Morphological Features in *IMORFE*)**
Time-step at which shoal volumes are printed as output (determined by *NSPR*)	Shoal volume (length^3) at each shoal output time-step

PRODUCT DEVELOPMENT AND AVAILABILITY: Cascade is available to both U.S. Army Corps of Engineers (USACE) and non-USACE interested parties. For USACE employees, Cascade can be obtained by e-mailing to "SMS" in the Global Address Book. For non-Corps parties, please contact EMS-I at sales @ems-i.com.

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please consult https://swwrp.usace.army.mil/ or contact the Program Manager, Dr. Steven L. Ashby at Steven.L.Ashby@erdc.usace.army.mil. Questions about this technical note may be addressed to Mr. Connell at (601-634-2840; Kenneth.J.Connell@erdc.usace.army.mil). This technical note should be cited as follows:

> Connell, K. J., and N. C. Kraus. 2006. *Cascade Version 1: User's guide.* ERDC TN-SWWRP-06-5, Vicksburg, MS: U.S. Army Engineer Research and Development Center. https://swwrp.usace.army.mil/

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